Advanced Materials, Chemical Technology, and Manufacturing (AM Topic)

Proposal Due Date: June 13, 2007

Rapid advances in new technologies which leverage multidisciplinary synergies across the boundaries of science and engineering are directly impacting businesses, consumers and society as a whole, and creating significant opportunities for small businesses to compete in the global marketplace. NSF is committed to supporting scientific discoveries that benefit the marketplace and encourage private sector investment in commercialization of these technologies. NSF seeks to support high-risk, high-payoff research aimed at substantially increasing the competitive capability of our nation's industries. Novel technologies and systems aimed at achieving increased performance, reductions in cost and/or improvements in quality are of particular interest. The ultimate goal is to provide a competitive advantage for the U.S. industries that are losing their position in today's marketplace due to fierce overseas competition.

The Advanced Materials, Chemical Technology, and Manufacturing (AM) topic is subdivided into four areas: (1) Energy Challenge; (2) Advanced Materials; (3) Chemical Technology; and (4) Manufacturing. The Energy Challenge is an over-arching area whose main purpose is to cluster all energy related proposals under one heading. The Advanced Materials, Chemical Technology and Manufacturing areas follow. **Note that the selection of the appropriate topic and a specific sub-topic should be based on where the innovation lies.**

Please direct topic/subtopic inquiries to the specific SBIR/STTR Program Director listed below:

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The Energy Challenge

The large projected increases in global population and energy demand provide unique opportunities for innovative solutions. The Advanced Materials, Chemical Technology and Manufacturing Topic of the NSF SBIR/STTR Program seeks to accelerate energy-related industrial innovation in the US by leveraging high technology capabilities of small businesses based upon fundamental scientific research and engineering innovation. The

Energy Challenge has been divided into two areas: (1) Supply, Delivery, and Use; and (2) Transportation and Fuels. The examples below are representative; however, not all encompassing. Please contact the appropriate Program Director if you have questions regarding your proposed topic.

A. Energy Supply, Delivery and Use

Numerous opportunities exist for electricity supply, delivery, and use in the areas of advanced materials, chemical technologies, and manufacturing.

A.1. Direct Conversion and Utilization of Thermal Energy

The vast majority of energy usage in industrial processes is in the form of heat. Much of the heat is released into the environment. Proposals are sought in the area of improved energy efficiency of thermal systems.

A.2. Buildings

Major steps to reduce energy needs for the built environment are essential. Potential solutions could include:

- New façade systems
- Insulating materials
- Lighting innovations
- Materials

A.3. Electrochemical energy conversion and storage technologies

Large-scale inexpensive storage can significantly change the landscape of energy markets. Major advances are needed in the areas of energy density, cost, and durability. Potential Advanced Materials, Chemical Technology, and Manufacturing Innovation proposals are:

- Novel processes to produce electrocatalysts
- Battery storage
- Hydrogen storage materials

A.4. Coal and Carbon Sequestration

Coal is the most abundant energy resource in the US, China, and India. It is also relatively inexpensive and supplies half of the US electricity use. The challenges for coal-based power generation are environmental. Approximately 80% of US emission from electricity production is CO_2. If CO_2 is successfully captured, safe and economical storage is required. Innovative proposals are sought in the area of Carbon Sequestration.

A.5 Renewables

Renewables hold the promise of addressing security and environmental concerns. Advanced Materials, Chemical Technology, and Manufacturing innovations are sought in the renewable areas of:

- Solar Energy
- Wind Energy

A.6 Energy Efficient Applications

Projects aimed at improving energy efficiency applications related to manufacturing processes including melting, heat treating, and hot working operations.

B. Transportation and Fuels

B.1. Transportation

The global transportation sector is highly dependent on petroleum-based liquid fuels. Example areas for which proposals are sought include:

- Improving efficiency and emissions reductions in engines
- Alternative fuel options (proposals in the area of biofuels should be submitted to Biotechnology Topic area (BT))
- Robust and Efficient Fuel Cell and Battery technologies
- Vehicle weight reduction through use of new materials

B.2 Hydrocarbons

Enhanced recovery methods from existing reservoirs could significantly improve petroleum availability. Advanced materials, chemical technology, and/ or manufacturing innovation topics in this area include:

- Innovative approaches to physical and/or chemical stimulation of existing reservoirs
- Emerging coal gasification techniques to produce a wide spectrum of products including liquid fuels

B.3. Transportation Power Trains

Potential opportunities exist to improve internal combustion engines and hybrid systems. Examples include:

- The use of onboard fuel reforment technology to maintain or improve the fuel economy of diesel engine vehicles, while meeting emission regulations
- NOx reduction

Advanced Materials

Advanced Materials area seeks proposals that focus on the development of new materials that can advance the competitive nature and state of the art for the U.S. industry. New materials and systems that have potential for revolutionary changes and paradigm shifts will be given special consideration.

Proposals must be market-driven and identify the end users of the proposed technology, and its potential for commercialization.

The focus of the Advanced Materials area is on **Materials Innovation**. Innovative projects to develop new classes of Materials and/or Material Systems are solicited. Of interest are materials of high quality and reproducibility, with superior properties for potential applications, obtained through chemistry, morphology, and processing variables. If the focus of the proposed research is on *manufacturing process innovation*, then please select the Manufacturing Innovation Topic and select appropriate sub-topics from that list. Materials development proposals addressing energy related applications should be submitted to the Energy Challenge sub-topic.

The following topics and sub-topics are addressed under the Advanced Materials. Please select one appropriate topic and a specific sub-topic within that broad area for the proposed research.

C. High-temperature Materials

C.1 Refractory metals and alloys

C.2 Metals, Ceramics and Composites for high-temperature applications; e.g. materials for advanced gas turbines, metal casting molds/dies, materials for dies used in various hot working processes (forging, extrusion), furnaces, and severe environments; innovative light-metal alloys

C.3 Materials to combat high-temperature erosion, corrosion and environmental degradation

C.4 High-temperature polymer materials

D. Engineered Structural Materials - Materials and systems from the macro- to the nano-scale *with engineering applications other than those listed above*

D.1 Materials, including polymers, with improved mechanical properties (strength, toughness, fatigue and fracture resistance)

D.2 Advanced composite materials for structural applications

D.3 Novel structural materials using unique processing techniques

D.4 “Smart” Materials; e.g. shape-memory alloys, environmentally adaptive materials, excluding coatings (see topic G.4)

D.5 Advanced (metal/polymer/ceramic matrix) composites

D.6 Structural foams and other lightweight

D.7 Novel abrasives, adhesives, pigments, sealants, fillers, additives, binders and lubricants

D.8 Advanced materials *engineered at the nanoscale and designed at atomistic scale*

D.9 Carbon-based materials (e.g., carbon nanotubes, nanofibers, fullerenes)

D.10 Multi-functional materials addressing thermal management, electronic, optical, structural,and magnetic properties, conformability, etc

D.11 Functional materials designed to meet specific properties (magnetic, rheological, expansion, conductivity, thermo-electric, etc)

E. Corrosion-resistant Materials

E.1 Advanced materials to combat aqueous corrosion (e.g., marine environment, chemical pollution, etc.)

E.2 Materials to combat aqueous/environmental corrosion (excluding high-temperature corrosion; see topic C.3), stress corrosion

E.3 Corrosion-resistant coatings and surface modifications

F. Tribological and Wear-resistant Coatings

F.1 Coatings and surface modifications to combat erosion and wear

F.2 Coatings and surface modifications to reduce friction

F.3 Materials improvements in tribological applications

G. Surface Modifications and Thin Film Technologies

G.1 Novel materials, coatings and surface engineering via vapor deposition techniques

G.2 Novel materials, coatings and surface engineering via laser deposition, infrared (IR) processing, ion implantation, ion-beam assisted deposition (IBAD) techniques

G.3 Materials and treatments using hybrid deposition techniques

G.4 "Smart" coatings for sensor applications

G.5 Surface modification of powders

H. Powdered Materials

H.1 Metals and alloys, including refractory materials

H.2 Ceramics

H.3 Mechanically alloyed materials

H.4 Composite materials

I. Biomaterials

I.1 Biopolymers

I.2 Implants

I.3 Coatings

I.4 Medical devices

I.5 Biomaterials for pollution mitigation, including air, water, soil and marine environments

J. Geomaterials

Innovative use of geomaterials to build products including electronics, structures, etc

K. Materials for Sustainability

K1. Biodegradable materials (not necessarily biomaterial)

K2. Designing for recyclability, including separation techniques

K3. Novel material systems that use significant levels of recycled materials

Chemical Technology

Innovative techniques that involve the transformation and transport of matter and energy with the focus of contributing the knowledge base of industrial manufacturing, as well as natural processes are of interest. The Chemical –based Technologies (CT) Topic supports research that involves the development and commercialization of processes and/or products based upon fundamental engineering principles, mathematical models, and experimental techniques, with an emphasis on projects that have the potential for innovation and broad application in areas such as the environment and chemical processing.

The CT Topic seeks proposals in the areas of separations, catalysis, photochemical and electrochemical systems, fluid flow, combustion related processes, thermal analysis, and molecular design. Applications of these technologies in the marketplace can range widely in the areas gas and liquid separation processes; single and multiphase processes and computation fluid dynamics; reactor and heat exchanger design; molecular modeling; and chemical characterization. Energy related proposals should be submitted to the Energy Challenge.

L. Separations Applications

Research is needed to develop highly selective, energy-efficient, and economic processes and effective mass-separating agents (e.g. membranes, adsorbents, extractants) for the separation and purification of all types of substances. Examples areas include

- environmentally benign liquid and gas separations of organics (e.g., olefins), inorganics (e.g., minerals), and
- critical and strategic metals.

Membranes used in separation applications for fuel cell are of interest. Please see the Energy Challenge within the AM Topic

M. Novel Catalytic Systems

Areas of interest include preparation of new catalysts or catalytic systems and of new uses for known catalysts. Applications may include

- consumer products,
- chemical production.

Proposals for developing improved techniques for integrating catalysts into fuel cells should be submitted to the Energy Challenge within the AM Topic.

NOTE: For pharmaceutical innovations, see Biotechnology (BT) topic.

N. Photochemical or Electrochemical Applications

- Novel applications of radiation to affect chemical reactions
- Innovative electric current applications to affect chemical reactions

Battery, fuel cell and solar energy related proposals should be submitted to the Energy Challenge within the AM Topic.

O. Fluid Flow Applications

Proposals are solicited that aim at improving the commercial applications of fluid engineering or particle technology processes or phenomena leading to advances with significant industrial impact.

- Improved systems related to single phase and multi-phase fluid flow
- Novel spraying applications
- Innovative particle technology applications
- Computational software related to the modeling of industrially applicable processes (non-IT related)

P. Combustion-Related Processes

Proposals are solicited on uses of combustion in industrial applications. For example, proposals might address innovative concepts for combustion to synthesize a specific product of economic value; and diagnostic techniques that can function in a high-temperature or high-field environment.

- Use of combustion to synthesize a specific product
- Applications for combustion of gaseous, liquid or solid fuels

Q. Reactor Engineering Applications

Commercialization of research in the areas of chemical reaction engineering encompassing the interaction of transport phenomena and kinetics in reactive systems and the use of this knowledge to design complex chemical reactors is of interest. Research areas of interest include, but are not limited to

- Membrane reactor systems
- Supercritical fluid applications

R. Chemical Design and Synthesis

Research is needed for the design and synthesis of new organic and inorganic substances that enable the testing of theoretical, mechanistic, or structural hypotheses with commercial promise. For example, proposals might address:

- Molecular-level design
- Synthesis of novel molecules
- Characterization techniques for chemical systems, surfaces or interfaces

Manufacturing Innovation

Projects that make the country's manufacturing base more competitive through innovation and response to changing needs are encouraged. Innovation in this context is fostered by research and development (R&D) of technologies that are aimed at increasing the competitive capability of manufacturing firms. In a broad context, manufacturing-related R&D encompasses innovation in existing methods or processes; improved education and training of competent work force with the aim of getting maximum benefit from existing or new methods or processes; or wholly new processes, machines or systems. The overall goal is to support new and emerging manufacturing innovation that will advance the competitiveness of the nation's manufacturing sector.

Manufacturing Innovation topics are grouped into **five broad areas of interest**:

S. Unit Process Level Technologies
T. Machine Level Technologies
U. Systems Level Technologies
V. Workforce Capability and Environmental Protection
W. Manufacturing Simulation Technologies

Please select **one specific sub-topic** within that broad area for the proposed research.

S. Unit Process Level Technologies: Projects that Create or Improve Manufacturing Processes, including:

S1. Additive Processes – projects aimed at advancing rapid prototyping/solid preform fabrication for material and process improvements

S2. Deformation Processes – projects aimed at advancing forging, extrusion, rolling, and sheet metal processing and punching for material property improvements based on the advances in the processes

S3. Joining and Assembly Processes – projects aimed at joining similar and/or dissimilar material combinations including welding, soldering, brazing, diffusion bonding, and adhesive processes

S4. Surface Engineering Processes – projects aimed at CVD, PVD, laser, thermal spray, electrochemical methods, innovative plasma or other diffusion treatment processes for surface property enhancement (ex: cleaning and surface preparation), duplex coating and hybrid processes

S5. Powder Material Processes – projects aimed at advancing powder-based materials/processes that include powder metals, powder ceramics and hybrid materials; processes include powder consolidation methods (sintering, injection molding, mechanical milling, lased cladding, near net shape manufacturing techniques, die compaction, field assisted electromagnetic consolidation of powders) and similar hybrid methods

S6. Casting/Molding Processes – projects aimed at improved efficiency/control in processing for high pressure, high velocity die casting, low pressure permanent mold, gravity permanent mold casting, semi-solid metal casting, investment casting and hybrid processes (ex: casting and forging)

S7. Polymer Processing – projects aimed at creating or improving manufacturing processes for various types of polymers including polymer matrix composites (PMC), surface engineering including polymer treatments for polymers

S8. Ceramic Processing – projects aimed at creating or improving manufacturing processes for various types of ceramics including ceramic matrix composites (CMC)

S9: Metal Matrix Composite Manufacturing – projects aimed at creating or improving manufacturing processes for metal matrix composites (MMC)

S10. Sensor Manufacturing – projects aimed at creating or improving manufacturing processes for various types of sensors including gas combustion sensors, accelerometers/gyroscopes and low-cost micro-sensors particularly for applications in energy and power management

S11. Electro Mechanical Systems at Micro and Nano-Scales (MEMS & NEMS) – projects aimed at manufacturing systems with applications to accelerometers, shock resistant devices, wide temperature range devices, actuators, and communication devices involving high levels of integration and hermetic packaging

S12. Micro/Meso Scale Components – projects aimed at minitiarization of manufacturing systems, manufacturing equipment and processes for manufacturing micro/meso-scale components and products, handling and assembly of micro/meso-scale components

S13. Passive Nanotechnology Applications – projects aimed at creating or improving manufacturing processes for nanoparticles, nanofibers, nanocomposites, nanocoatings and carbon nanotubes

S14. Heat Treat Processes – projects aimed at **novel** heat treat processes including hardening techniques

S15. Non Destructive Inspection – projects aimed at creating new non-destructive inspection techniques for various materials

S16. Machining and Material Removal – projects aimed at process improvements for milling, grinding, drilling and cutting tools; non-traditional material removal processes (ex: EDM, plasma, water jet, laser-based micromachining, electrochemical machining and combinatorial techniques); high speed machining, dry machining and MQL

T. Machine Level Technologies: Projects that Create or Improve Manufacturing Equipment

T1. Machine Design – projects aimed at improving design of existing machines and equipment in order to improve efficiency and/or cost; modular design of machine component

T2. Machining and Material Removal – projects aimed at advances in machine tool design (ex: improved tool holder and part holder design)

T3. Metrology – projects aimed at improving machine tool calibration, and part inspection equipment

T4. Material Processing – projects aimed at innovation in processing equipment for MMC, PMC and CMC

T5. Deposition Equipment – projects aimed at developing new hardware or improving hardware component for deposition (ex: cathodic arc evaporation process, CVD, equipment for electrical insulating coating material, and "continuous" vs "batch" processing equipment

T6. Disassembly and Sorting Equipment – projects aimed at development of new and innovated machinery to disassemble end of life products and sort components in material groups

T7. Process Control – projects aimed at in-process sensing technology and sensor technology integration

U. Systems Level Technologies: Projects that Create Innovation in the Manufacturing Enterprise

U1. Intelligent Process Control – projects aimed at development of manufacturing system control methodologies using artificial neural logic network

U2. Manufacturing Enterprise Systems – projects aimed at decision tools for supply chains, planning, scheduling, distribution, and risk optimization for the extended and spatially distributed enterprises

U3. Six Sigma – projects aimed at developing new methods and/or equipment for implementation of lean manufacturing

V. Workforce Capability and Environmental Protection: Projects that Improve Workforce Capabilities and Manufacturing

V1. Workforce Capability – projects aimed at improving the manufacturing work environment (including reducing worker exposure to hazardous environment) by incorporating ergonomics and interactive computing systems

V2. Environmental Cleanup – novel systems that use significant levels of recycled materials and projects aimed at improving techniques for recycling of materials

V3. Plastics Scrap Sorting Process – projects aimed at developing innovative methods and processes to separate many different grades of plastics obtained from household and consumer level waste

V4. Virtual Manufacturing – projects aimed at technology to run machines remotely

W. Manufacturing Simulation Technologies

W1. Residual Stress Prediction – projects aimed at accurately predicting residual stress introduced in many manufacturing methods such as casting, forging, machining, and heat treatment

W2. Distortion Prediction – projects aimed at predicting an actual shape (not the theoretical shape) formed during and after various manufacturing methods

W3. Physical/Mechanical Properties Prediction – projects aimed at accurately predicting local mechanical properties in components made using various manufacturing processes

W4. Initial/Boundary Condition Definition - projects aimed at obtaining appropriate initial and boundary conditions necessary for manufacturing simulation experimentally and numerically